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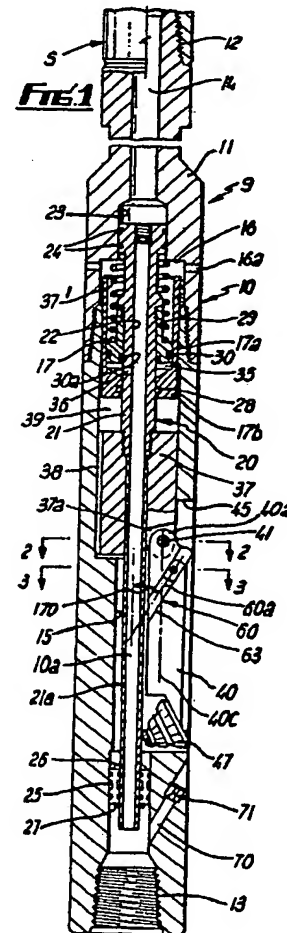
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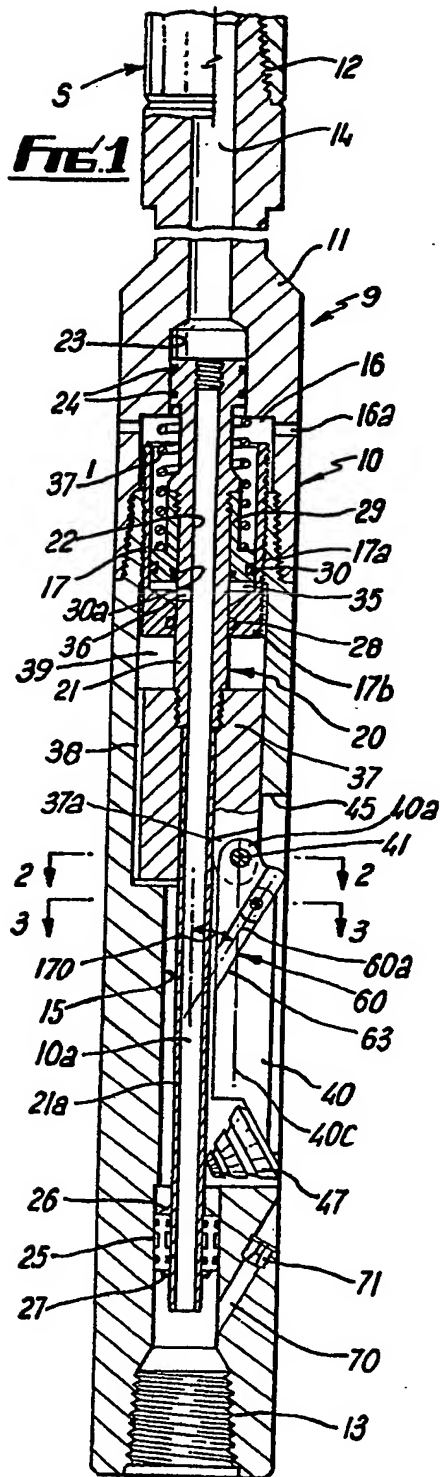
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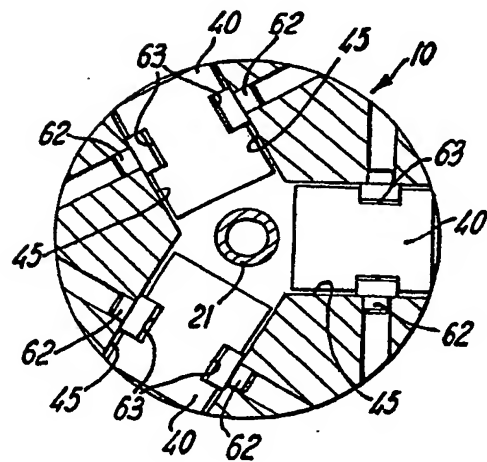
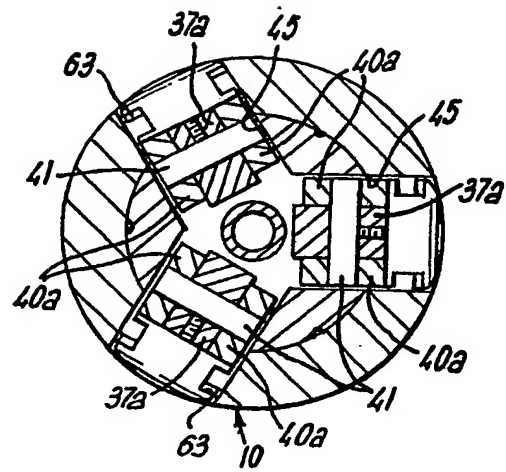
(54) Borehole reamer

(57) A bore hole enlarging method and arrangement for connection with a rotary pipe string 5 includes inner and outer body sections 20 and 11 which form a body structure 10 to provide a fluid flow path therethrough for communicating with piston 29 and cylinder 17 formed between the body sections for receiving drilling fluid to effect telescopic movement between the body sections. Cutter arms 40 are pivotally mounted on the inner body section 20 and a cooperable support arrangement 60 on the cutter arms 40 and outer body section 11 cooperate to expand or move the cutter arms 40 outwardly of the body structure 10 upon telescopic movement of the body sections in one relative direction and assist in retracting the cutter arms 40 when desired.

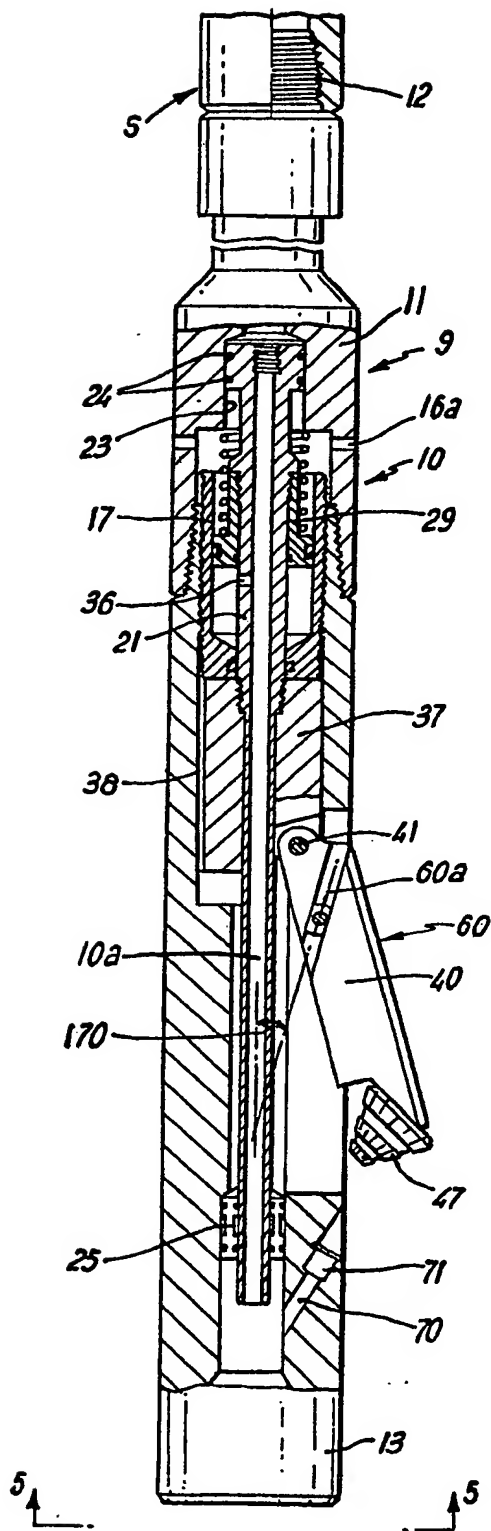




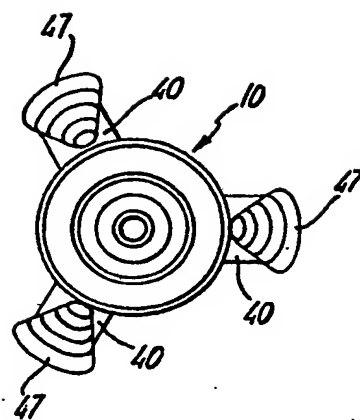
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**Fig. 4**



**Fig. 5**

string S for lowering in a well bore to enlarge, or underream a portion of the well bore.

The inner body section 20 includes a tube 21 extending longitudinally of the outer body section 10 as shown. The tube 21 includes a bore 22 therethrough which communicates with the bore 14 in the outer body structure for forming a fluid flow path that communicates with the connected well string for supplying drilling fluid to actuate the underreamer 9 as will be described.

The tube 12 is received within the counterbore 23 at the upper end of the outer body section 11 and is provided with seal means 24 for sealably engaging therewith. A chamber 16 is formed in the outer body section 11 and extends from the lower end of the counterbore 23 to the upper end of the longitudinal passage 15 in which is received the lower extension 21a of the tube 21 as shown. A seal bushing 25 is mounted on the tube extension 21a in any suitable manner such as by the annular shoulder or projection 26 on the tube 21a and the snap ring 27 which abuts the lower end of the seal bushing 25 to secure it with the tube extension 21a. The seal bushing 25 seals between the tube extension 21a and the passage 15.

The outer body section 11 is provided with passages 16a for communicating the well bore with the interior of chamber 16 for equalization of pressure therebetween. A cylindrical member 17 is secured with the outer wall section of outer body section 11 with chamber 16 as illustrated in any suitable manner such as by the threads 17a which threadedly engage the cylindrical walls of the cylindrical member 17 to the outer body section 10 within chamber 16. The lower end 17b of cylindrical member 18 is closed as shown.

The longitudinal tube 21 forming part of inner body section 20 extends through the closed end 17b of cylindrical member 17 as shown and is sealably engaged as shown at 28 with the lower closed end 17b of the cylindrical member 17. A piston member 29 is threadedly secured to the tube 21 and is thereby positioned within the cylindrical member 17. Annular seal 30 on piston member 29 engages the cylindrical walls of the cylindrical member 17 and seal 30a sealably engages piston member 29 on tube 21. This defines a means including the piston arrangement 29 and cylinder means 17 to effect telescopic movement of said body sections in one relative direction. More particularly, the space between the lower end of piston means 17 and the closed end 17b of cylinder means 29 defines between the inner body section 20 and outer body section 11 a chamber 35 for receiving from the well string pressured drilling fluid which flows through passage 14 in body structure 10, passage 22 and port 36 in tube 21 to act on the piston and cylinder means to effect telescopic movement of the outer body

section 11 and inner body section 20 in one relative direction to move the cutter arms 40 from the retracted position shown in Fig. 1 to the expanded position shown in Fig. 4.

Suitable spring means 37' abut at its upper end against the shoulder formed by the juncture of the chamber 16 with the counterbore 23. The lower end of the spring 37' rests on the top side of the piston means 29 to tend to urge the inner body section 20 and piston means downwardly to a position to tend to maintain the cutter arms 40 in retracted position. Stated differently, such spring means 37' inhibits telescopic movement between the inner body section 20 and outer body section 10 in said one relative direction.

To assist in maintaining alignment as well as providing other functions, a yoke member 37' is threadedly secured to the tube 21 as shown in the drawings and extends longitudinally in the lower part of the chamber 16 to accommodate relative longitudinal movement between the inner and outer body sections 20 and 11 while supporting and stabilizing the body structure during underreaming, or well bore enlarging operations. Suitable longitudinal groove means 38 are provided in the yoke member 37 to enable fluid pressure exteriorly of the body structure 9 to communicate with the chamber 39 above the yoke member 37 and equalize with that existing in the well bore, thus accommodating unrestricted longitudinal movement between the inner and outer body sections 20 and 11, respectively.

The yoke member 37 also supports the cutter arms 40, three of which are illustrated in the embodiment in the drawings. The cutter arms 40 are arranged in longitudinal slots 45 which are circumferentially spaced on the outer body 10 as shown in Fig. 2 and 3 of the drawings.

The cutter arms 40 are pivotally connected to the inner body 20 by means of the pivot pins 41 extending through the spaced upper ends 40a of the cutter arms 40 which ends 40a straddle circumferentially spaced, depending projections 37a formed on the lower end of the yoke member 37 as better illustrated in Figs. 1 and 2 of the drawings.

The lower end of each of the cutter arms 40 is provided with a drill bit 47 rotatably supported on the cutter arm in any manner well known in the art.

Heretofore, some difficulty has been encountered in conducting underreaming operations with devices of the prior art due to the forces and loads imparted to the cutter arms and body structure during the underreaming operations.

In an attempt to overcome these problems, the cutter arms of the present invention are not only pivotally mounted and supported on the inner body section 20, but cooperating means on the outer body section 11 and cutter arms 40 cooperate to support the cutter

arms on the outer body section 11 and assist in moving the cutter arms towards expanded and retracted position. Such arrangement also provides a mechanical advantage which advantage becomes greater as the cutter arms are moved toward expanded position and which advantage is maintained during bore hole enlargement operations to aid in maintaining the tool in open position, that is, to maintain the cutter arms 40 expanded during bore hole enlarging operations and to better absorb the loads and forces encountered during such operation.

One arrangement of such cooperating means is illustrated in the drawings and is shown as including the arrangement generally referred to at 60 which enables the outer body 11 to support the cutter arms 40 as they are expanded, and during bore hole enlargement operations, as well as assisting the cutter arms 40 in moving towards retracted position. After bore hole enlargement operations have been completed, the body structure 9 is elevated to engage the cutter arms 40 against the ledge formed by the enlargement in the bore hole to assist in retracting the arms back into the body structure 9 as shown in Fig. 1 of the drawings. The arrangement 60 provides an interfitting arrangement and includes suitable means on the outer body section 10 which moveably interfits with each cutter arm 40 and assists in urging and moving the cutter arms 40 to retracted position, as opposed to merely breaking the cutter arms.

In the embodiment illustrated in the drawings, such interfitting arrangement is shown as including projecting means 62 mounted on the outer body section 11 and which projects inwardly into the longitudinal slots 45 as better illustrated in Fig. 3 of the drawings. A groove means 63 is formed on each side of and extends diagonally relative to the longitudinal axis, represented at 40c, of each cutter arm 40 and receives the projections 62 therein as shown.

When the cutter arms 40 are in retracted position as shown in Fig. 1, the angle represented at 70 between the longitudinal axis of the body 10a structure 10 and the longitudinal axis 60a of the arrangement 60 (defined by the longitudinal axis of the groove means 63) is larger than the same angle represented at 70 when the cutter arms 40 are moved to expanded position as shown in Fig. 4. Since the angle 70 is smaller when the cutter arms 40 are moved to expanded position for performing underreamer or bore hole enlargement operations, the mechanical advantage of the present invention becomes larger when the arms are moved to expanded position and thereby provides a structure which tends to maintain the cutter arms 40 in expanded position during well bore enlarging operations.

The cylinder means 17 provide a means to adjustably limit the telescopic movement of

the body sections and thereby provides a range of hole enlargement diameters that may be attained with a particular body size structure. For example, and by illustration only, assume that the body structure 10 is 11-3/4" O.D. This same body size, by adjusting the longitudinal position of the cylinder member 17 in chamber 16 can be used to underream a 17-1/2" hole, 20", 22-1/2" or 24" hole, or any desired size from 17-1/2" through 24" O.D.

Where it is desired to perform a larger diameter underream, a larger body size would be employed to cover a range of larger underream diameters. This overcomes some of the problems encountered with prior art devices which require that some component of the underreamer or bore hole enlarger be changed for each hole diameter desired. In the present invention, merely by threading the cylinder means 17 longitudinally of the chamber 16 and body structure 10, the desired underream outer diameter may be attained. The longitudinal position of the cylinder means 18 acts as a stop means for the upper end of the yoke means 37 and thus determines the amount of extension of the cutter arms 40 and hence the outer diameter of the enlargement or underreaming portion to be formed.

The upward end force encountered by the drill comes 47 during underreaming operations reacts to assist in keeping the arms expanded during the underreaming operations by reason of the foregoing construction of the present invention. Also, where the present invention is used to underream or enlarge in a high angle well bore hole, and with the arms engaging the low side of the well bore, there is a tendency for the radial load to close or retract the arms of some prior art devices; however the force acting on the end of the cones in an upward direction, as the underreaming device moves downwardly during the underreaming operations and arrangement 60 assists in keeping the arms extended and resists the radial closing of the arms.

The structural arrangement of the present invention as shown in the drawings provides as much body support as possible to the arms since the arms are supported by both the inner and outer body structures in their extended position which inhibits wobbling as well as wear on the components of the invention, which wear can be aggravated by the presence of mud encountered during the enlarging operation that may act to grind or wear down components of some prior art devices more readily than that which would occur with the present invention due to the stabilizing effect of the yoke member 37 and of the interfitting supporting arrangement 60 between the outer body and the cutter arms 40.

As previously noted, after the underreaming operation is completed, retraction of the cutter arms 40 is accomplished by lifting or raising

the pipe string in the well bore on which the body structure 10 is carried so that the cutter arms 40 in their extended position engage the upper end of the completed underreamed or enlarged portion in the well bore. In prior devices where it has been impossible to effect retraction of the arms by such engagement and subsequent pulling on the well string, it has been necessary to break some tool component by exerting a continued upward force on the well string so that the underreaming device thereafter might be recovered from the well bore.

However, in the present invention, even though the body structure may be immersed in mud, the force applied to the cutter arms 40 by engaging them with the ledge at the upper end of the enlargement acts to move the cooperating means 60 between the outer body section 10 and the cutter arms from the position shown in Fig. 4 to the position shown in Fig. 1. In this instance also, the mechanical advantage is increased as the cutter arms move from expanded to retracted position since the angle 70 increases from that shown in Fig. 4 to that shown in Fig. 1.

A passage 70 in outer body section 11 adjacent the lower end thereof is provided with a carbide nozzle insert 71 and retained in position in passage 70 by means well known in the art. This enables drilling fluid to be conducted from the flow passage in the body structure 10 and directed against the cones 47 to assist in removing cuttings and debris therefrom during underreaming operations.

After underreaming operations are completed, the pump pressure acting on the drilling fluid is relieved and when weight of the well string is removed from body 10 spring 37' tends to move the inner body section 11 back to the position shown in Fig. 1. However, the arms 30 may be engaged with the shoulder at the top of the underream section and by applying a pull on the well string, the cooperating arrangement 60 assists in moving the cutter arms 40 to retracted position.

The foregoing disclosure and description of the invention are illustrative and explanatory thereof, and various changes in the size, shape and materials as well as in the details of the illustrated construction may be made without departing from the spirit of the invention.

#### 55 CLAIMS

1. A bore hole enlarging arrangement for connection with a rotary pipe string having a drilling fluid flow path comprising:  
a body structure including inner and outer  
60 telescopic body sections;  
expansible and retractable cutter arms on said inner body section;  
engaging means on said outer body section and said cutter arms to expand said cutter  
65 arms upon telescopic movement of said body

sections in one relative direction; and means to effect telescopic movement of said body sections.

2. The arrangement of claim 1 including means to inhibit telescopic movement of said body sections in said one relative direction.

3. The arrangement of claim 1 wherein said last named means includes piston and cylinder means defined between said inner and outer body sections and passage means in said body structure for conducting drilling fluid to said piston and cylinder means to effect telescopic movement of said body sections.

4. The arrangement of claim 1 wherein said engaging means includes means mounted on said outer body section and movably engaging said cutter arms.

5. The arrangement of claim 1 including means to adjustably limit the telescopic movement of said body sections and thereby provide a range of hole enlargement diameters that may be attained with said body structure.

6. The arrangement of claim 1 wherein said outer body section includes circumferentially spaced, longitudinal slots for receiving said cutter means, and wherein said engaging means includes groove means in said cutter arms and means on said outer body section projecting into said slots to engage within the groove means in said cutter arms.

7. A hole boring enlarging arrangement for connection with a rotary pipe string having a drilling fluid flow path comprising:

a body structure including inner and outer  
100 telescopic body sections;  
expansible and retractable cutter arms pivotally mounted on said inner body section;  
means on said outer body section supporting said cutter arms for expansion outwardly of said outer body section upon telescopic movement of said body sections in one relative direction; and  
means to effect telescopic movement of said body sections.

8. The arrangement of claim 1 including biasing means tending to bias said expanded cutter arms toward retracted position.

9. The arrangement of claim 8 wherein said biasing means biases said inner body section downwardly.

10. The arrangement of claim 7 including cooperating support means on said outer body section and cutter arms engageable to increase the mechanical advantage tending to maintain the cutter arms in expanded position during bore hole enlarging operations.

11. A method of conducting bore hole enlarging operations with a rotary pipe string that carries a body structure having a drilling fluid flow path therethrough, the body structure including inner and outer telescopic body sections with expansible and retractable cutter arms pivotally mounted on the inner body section and supported in the outer body section for movement to expanded and retracted posi-

tion, comprising the steps of:

lowering the rotary pipe string and body structure to position in the bore hole;

circulating drilling fluid in the body structure  
5 to effect telescopic movement of the body sections in one relative direction and thereby expand the cutter arms; and

changing the physical relationship between the longitudinal axis of the body structure and  
10 the longitudinal axis of the support in the outer body section for the cutter arms when they are expanded to increase the mechanical advantage tending to maintain the cutter arms expanded during bore hole enlarging operations.  
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12. In a bore hole enlarging arrangement including a body structure for connection with a rotary pipe string, the body structure having a drilling fluid flow path therethrough, inner  
20 and outer telescopic body sections which define piston and cylinder means between said body sections for receiving drilling fluid to effect telescopic movement in one direction between said body sections whereby cutter  
25 arms supported on the body structure may be expanded, the improvement comprising:

pivot means pivotally mounting the cutter arms on said inner body section; and

cooperating means on the outer body section and the cutter arms operable upon telescopic movement of said body section in said one relative direction to decrease the angle  
30 formed between the longitudinal axis of the body structure and a longitudinal axis of said cooperating means to thereby increase the mechanical advantage tending to maintain the cutter arms expanded during bore hole enlarging operations.  
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13. The arrangement of claim 1 wherein said engaging means includes a cooperating interfitting arrangement to support said cutter arms on said cutter body section and accommodating expansion and retraction of said cutter arms relative to said outer body section.  
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14. The invention of claim 6 wherein said groove means in said cutter arms extend diagonally of the longitudinal axis of said cutter arms.  
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15. A bore hole enlarging arrangement substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.  
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16. A method of conducting bore hole enlarging operations substantially as hereinbefore described with reference to the accompanying drawings.  
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#### CLAIMS

Amendments to the claims have been filed, and have the following effect:—  
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Claims 1 to 16 above have been deleted or textually amended.

New or textually amended claims have been filed as follows:—

65 1. A bore hole enlarging arrangement for

connection with a rotary pipe string having a fluid flow path comprising:

a body structure including inner and outer telescopic body sections;

70 expansible and retractable cutter arms pivotally supported on said inner body section; said outer body section having circumferentially spaced, longitudinal slots for receiving said cutter arms;

75 longitudinally extending groove means with projection means interfitting therewith for connecting said cutter arms with said outer body section to pivotally support said cutter arms in the longitudinal slots of said outer body section; and  
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fluid actuated means to move said inner body section upwardly relative to said outer body section and thereby effect relative movement between said projection means and said  
85 groove means to expand said cutter arms outwardly of said outer body section.

2. The arrangement of claim 1 including means to inhibit telescopic movement of said body sections in said one relative direction.

3. The arrangement of claim 1 wherein said last named means therein includes piston and cylinder means defined between said inner and outer body sections and passage means in said body structure for conducting fluid to  
90 said piston and cylinder means to effect upward movement of said inner body section.

4. The arrangement of claim 1 including means adjustable longitudinally on said outer body section and through which said inner  
95 body section extends to adjustably limit the telescopic movement of said body sections and thereby provide a range of hole enlargement diameters that may be attained with said body structure.  
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5. The arrangement of claim 1 wherein said longitudinally extending groove means extends diagonally relative to the longitudinal axis of said cutter arms.  
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6. A hole boring enlarging arrangement for connection with a rotary pipe string having a drilling fluid flow path comprising:

a body structure including inner and outer telescopic body sections;

expansible and retractable cutter arms pivotally mounted on said inner body section;  
110 said outer body section having circumferentially spaced, longitudinal slots for receiving said cutter arms;

groove means on opposed sides of each of said cutter arms and projection means on said outer body section extending into said longitudinal slots and within said groove means to pivotally support said cutter arms in the longitudinal slots of said outer body section; and  
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fluid actuated means to move said inner body section upwardly relative to said outer body section and thereby effect relative movement between said projection means and said groove means to expand said cutter arms outwardly of said outer body section.  
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7. The arrangement of claim 1 including means to move said inner body section downwardly relative to said outer body section and thereby effect relative movement between said groove means and projection means to retract said cutter arms toward said longitudinal slots in said outer body section.

8. The arrangement of claim 6, including means to move said inner body section downwardly relative to said outer body section and thereby effect relative movement between said groove means and projection means to pull said cutter arms toward said longitudinal slots in said outer body section.

9. The arrangement of claim 1, including means to move said cutter arms from expanded to retracted position.

10. A method of conducting bore hole enlarging operations with a rotary pipe string that carries a body structure having a fluid flow path therethrough, the body structure including inner and outer telescopic body sections with expansible and retractable cutter arms pivotally mounted on each the inner and outer body section for movement to expanded and retracted position, comprising the steps of;

lowering the rotary pipe string and body structure to position in the bore hole;  
circulating fluid in the body structure to effect upward movement of the inner body section relative to the outer body section and thereby expand the cutter arms and to decrease the angle formed between the longitudinal axis of the body structure and the longitudinal axis of the pivot mounting of the cutter arms on the outer body section for increasing the mechanical advantage tending to maintain the cutter arms expanded during bore hole operations.

11. In a bore hole enlarging arrangement including a body structure for connection with a rotary pipe string, the body structure having a drilling fluid flow path therethrough, inner and outer telescopic body sections which define piston and cylinder means between said body sections for receiving drilling fluid to effect telescopic movement in one direction between said body sections whereby cutter arms supported on the body structure may be expanded, the improvement comprising:

pivot means pivotally mounting the cutter arms on said inner body section; and cooperating means on the outer body section and the cutter arms operable upon telescopic movement of said body section in said one relative direction to decrease the angle formed between the longitudinal axis of the body structure and a longitudinal axis of said cooperating means to thereby increase the mechanical advantage tending to maintain the cutter arms expanded during bore hole enlarging operations.

12. The invention of claim 7 wherein said groove means in said cutter arms extend dia-

gonally of the longitudinal axis of said cutter arms.

13. A method of forming an enlargement in a bore hole with a shoulder at the juncture of the enlargement and bore hole by lowering into the bore hole a rotary pipe string that carries a body structure having a fluid flow path therethrough, the body structure including inner and outer telescopic body sections with expansible and retractable cutter arms pivotally mounted on each the inner and outer body section for movement to expanded and retracted positions, comprising the steps of:

lowering the rotary pipe string and body structure to position in the bore hole;  
circulating fluid in the bore structure to effect upward movement of the inner body section relative to the outer body section and thereby expand the cutter arms to form the enlargement upon rotation of the pipe string; and

elevating the well string to engage the cutter arms with the enlargement shoulder and to move the inner body section down and thereby pull the cutter arms to retracted position.

14. A bore hole enlarging arrangement substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

15. A method of conducting bore hole enlarging operations substantially as hereinbefore described with reference to the accompanying drawing.

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